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OSMOTIC DEHYDRATION OF FISH (NGA-YANT, SNAKEHEAD MURREL)

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Abstract

Osmotic dehydration is an operation used for the partial removal of water from food tissues by immersing in an osmotic solution. It has potential advantages of less heat damage, better retention of flavour and energy saving method to produce the food products. Osmotic dehydration of fishes (Nga-yant, Snakehead Murrel) were conducted by varying the process parameters such as types of osmotic solution, size of the samples, immersion time, osmotic temperature, and sample to osmotic solution ratio. The osmo-treated dried fishes were analysed with respect to their weight reduction (WR), solute gain (SG), water loss (WL), and dehydration efficiency index (DEI).Then osmotic drying kinetics of fishes (Nga-yant) were carried out by varying the drying temperature with different drying time. The drying rate constant, k for Nga-yant was 0.0073 min^{-1} with drying temperature of 80ºC. Physico-chemical characteristics of osmo-treated dried fishes were also determined. The total plate counts (TPC) of osmo-treated dried, osmo-treated sun-dried and sun-dried samples were determined. These results prove that the process of osmotic dehydration has an important influence on the reduction of total number of micro-organisms in the samples. The organoleptic properties of products were also determined by the 9-Point Hedonic Scale Rating Test. The results of scores from sensory test, it was considered that the products of fishes were greater than 7, thus the osmotic dehydrated fishes were good quality products. The morphology of sun-dried samples and osmo-treated dried samples were compared by using SEM micrographs.

Keywords: Osmotic dehydration, osmotic solution, immersion time, drying rate constant

Introduction

Fishes are highly perishable product in nature which can be rapidly deteriorated caused by the biochemical activities. Some preserved methods for fish are smoking, salting, and drying. Salting of fish is an essential process of osmotic dehydration (Oladele et al., 2008). Osmotic dehydration is a common

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method for fruits and fishes to obtain several kinds of product as minimally processed or as intermediate moisture products, as a pretreatment in drying. The process can be used to achieve fishes with distinct characteristics, obtain foods with prolonged shelf life, or produce consumable products. It can be used as a previous step for further operations such as drying, freezing, canning, frying (Raoult-Wack, 1994). Osmotic dehydration is an operation which improves nutritional and sensorial properties without varying intrinsically (Torreggiani, 1993). Basic purposes of food dehydration involve decreasing of water contents, minimizing rate of chemical reactions, facilitating for distribution (Fito, et al., 2003). The osmotic dehydration process follows by convective drying may assist from prevent some objectionable structural changes on foods, promotes stabilization of color by reducing non-enzymatic browning reactions and increases flavor of food (Pereira, et al., 2006).

Materials and Methods

Raw Materials

Freshwater fishes of Nga-yant (Snakehead Murrel) were purchased from Sanpya Market (obtained from Thonegwa Township) Thingangyun Township, Yangon Region. The average weights of the purchased fishes were about 0.489 kg (0.30viss). Sugar used in this research was the products of the Ministry of Agriculture, Livestock and Irrigation and salt was purchased from Sein Myittar Mon Salt Industry, Mingalar Taung Nyunt Township, Yangon Region.

Methods

Preparation of Raw Fishes (Nga-yant, Snakehead Murrel)

Fresh fishes of Nga-yant were washed, cleaned, beheaded and descaled. Then, the fishes were degutted and washed again. After washing, the skins of fishes were removed and the fish fillet samples were cut into slices of (5 x 5 x 0.5) cm^3.

Osmotic Dehydration Process of Prepared Raw Samples with Complex Osmotic Solution

The prepared raw samples (Nga-yant, Snakehead Murrel) were individually weighed and immersed in the ternary osmotic solution Type I (salt 20 g, sugar 10 g, DW 70 ml) for 120 min. The weight ratio of sample to osmotic solution (1:5 w/w) was chosen for osmotic treatments. After the immersion, the samples were taken out from the osmotic solution and washed slightly with small amount of water. Then, the samples were blotted with absorbent paper to remove excessive water. The osmosed samples were reweighed and dried in a hot air oven at 80 °C for 3 hours. Then, the osmo-treated dried samples were taken out from the oven, cooled and reweighed.

The weights of osmo-treated dried samples were recorded for the determinations of weight reduction (WR), solute gain (SG), water loss (WL) and dehydration efficiency index (DEI).

The same procedure as described above was carried out by varying the types of ternary osmotic solutions (Type II (salt 25 g, sugar 15 g, DW 60 ml), Type III (salt 30 g, sugar 20 g, DW 50 ml), and Type IV (salt 35 g, sugar 25 g, DW 40 ml), Type V (salt 40 g, sugar 30 g, DW 30 ml)) while keeping the immersion time, size of samples, osmotic temperature (Room Temperature of 25-32°C), and sample to osmotic solution ratio (1:5 w/w) constant. The effect of types of ternary osmotic solution, size of samples, immersion time, osmotic temperature, and sample to osmotic solution ratio on weight reduction, solute gain, water loss and dehydration efficiency index were also studied.

Determination of Weight Reduction (WR), Solute Gain (SG), Water loss (WL) and Dehydration Efficiency Index (DEI)

The percent of weight reduction (WR) was determined by the change in weight of samples, solute gain (SG) was determined by the change in total solids with the initial weight of samples, water loss (WL) was calculated by the addition of (WR) and (SG) (Koprivica G., et al., 2011). Dehydration efficiency index (DEI) of osmo-treated dried Nga-yant sample was determined from the water loss and solute gain (Filpovic, et al., 2014).

Kinetics of Osmotic Dehydration

The kinetics of osmotic dehydration was determined by estimating the rate of water removal and solute gain. In addition, drying kinetics was conducted for using the same process with the temperatures of 70°C and 80°C. Finally, the drying data were fitted to the first order exponential equation in order to estimate the drying rate constant.

Determination of Drying Rate Constant (k)

Drying rate constant (k) for kinetic of osmotic dehydration process can be determined from Lewis equation (exponential equation), (Equation (1)), (Ndukwu, 2009). It can be simplified into Equation (3) in the form of the natural log of moisture ratio against time.

$$MR = \frac{M_t - M_e}{M_0 - M_e} = \exp^{(-kt)} \qquad \text{(Lewis equation)} \quad (1)$$

$$\ln MR = - kt \qquad (2)$$

$$k = - \ln MR \times \frac{1}{t} \qquad (3)$$

MR = Moisture ratio

M_t = Moisture content at time t (g/g)

M_o = Initial moisture content (g/g)

M_e = Equilibrium moisture content (g/g)

k = Drying rate constant (min^{-1})

t = Drying time (min)

Determination of Physico-chemical Characteristics of Fish Before and After Osmotic Dehydration and Examination of Microbial Constituents in Osmo-treated Dried Fishes

Some physico-chemical characteristics such moisture content, crude protein content, crude fat content, crude fiber content, carbohydrate content, ash content, energy value and physical properties such as color density and total plate count of osmo-treated dried fishes (Nga-yant) were determined by (AOAC 2000) method.

Determination of Organoleptic Properties

Organoleptic properties of osmo-treated dried Nga-yant were determined by 9-Point Hedonic Scale Rating Test. These properties were based on the appearance, flavour, texture and overall acceptability of samples. Ten panelist were asked to rate each sensory attribute on a 9-point hedonic scale form 1 (dislike extremely) to 9 (like extremely) (1: extremely poor, 3: poor, 5: acceptable, 7: good; 9: excellent) (Naknean et al., 2012).

Scanning Electron Microscopy

SEM was used to analyze the structural changes of osmo-treated and sun-dried products. It was conducted by using Electron Microscopy (JSM, 5610).

Results and Discussion

The results of osmotic dehydration of fishes evaluated with respect to weight reduction (WR), solute gain (SG) and water loss (WL) are presented in Tables (1) and (2). Osmotic dehydration of fishes were found to be directly related to compositions of osmotic solutions, thus showing that as solution concentration increases water loss also increases. The size of the sample effects on the behavior of weight reduction, solute gain and water loss during the process. From the results shown in Tables (2), it was observed that the thicker samples gave the lower water loss and solute gain value. On the other hand, it was occurred that the thinner samples gave higher weight reduction and water loss.

Table 1: Effect of Compositions of Ternary Osmotic Solution on Weight Reduction (WR), Solute Gain (SG), Water Loss (WL) and Dehydration Efficiency

Sr. No.	Types of Ternary Osmotic Solution	Initial Wt. of Slice (g)	WR (%w/w)	SG (%w/w)	WL (%w/w)	DEI
1	I	21.66	17.64	15.88	33.52	2.11
2	II	21.52	21.09	16.54	37.63	2.27
3	III	21.65	22.68	17.14	39.82	2.32
4	IV	20.41	25.33	22.54	47.87*	2.12
5	V	20.22	24.23	22.06	46.29	2.10

Index (DEI) * Most suitable condition
Ternary osmotic solution Type IV was chosen.

Table 2: Effect of Size of Sample on Weight Reduction (WR), Solute Gain (SG), Water Loss (WL) and Dehydration Efficiency Index (DEI)

Sr. No.	Size of Sample (cm^3)	Initial Wt. of Slice (g)	WR (%w/w)	SG (%w/w)	WL (%w/w)	DEI
1	5 x 5 x 0.3	13.90	37.98	25.17	63.15	2.51
2	5 x 5 x 0.5	20.49	36.75	25.72	62.47*	2.43
3	5 x 5 x 1.0	24.80	29.72	30.94	60.66	1.96
4	5 x 5 x 1.5	42.30	24.73	30.12	54.85	1.82

* Most suitable condition
Size of Sample (5 x 5 x 0.5) cm^3 was chosen.

The effect of each of the variables was shown by the plot for water loss and solute gain. According to the Figure (1), it was observed that immersion time of (300 min) was the most suitable condition for osmotic dehydration of Snakehead Murrel. The time of immersion had greater effect on water loss as observed in Figure (1) than solute gain. The effect of sucrose concentrations during the process was observed to be dependent on time to improve the degree of water loss. Therefore, immersion time is a very important variable in the osmotic dehydration of fishes.

The ratio of water loss and solute gain is the indicator of the optimization of osmotic dehydration treatment. From the Figures (2) and (3), an increase of sample to osmotic solution ratio resulted in an increase in both solute gain and water loss in osmotic dehydration. A large ratio was used to avoid significant dilution of the medium during the process. It was found that the increase proportions of solute in osmotic solutions, temperature of the process and duration of the process had led to the increase of water loss. The osmotic temperature exhibited relevance on water loss and solute impregnation was enhanced at higher temperature.

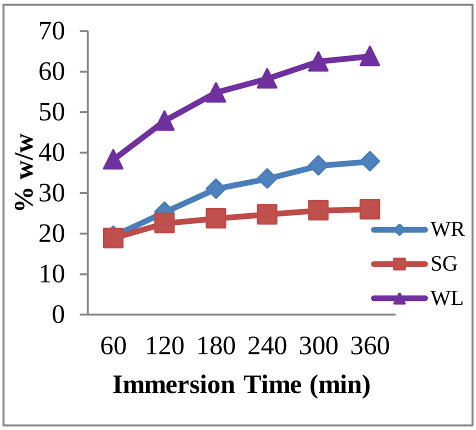


Figure 1: Effect of Immersion Time on Weight Reduction, Solute Gain, and Water Loss for Osmotic Dehydration of Nga-yant

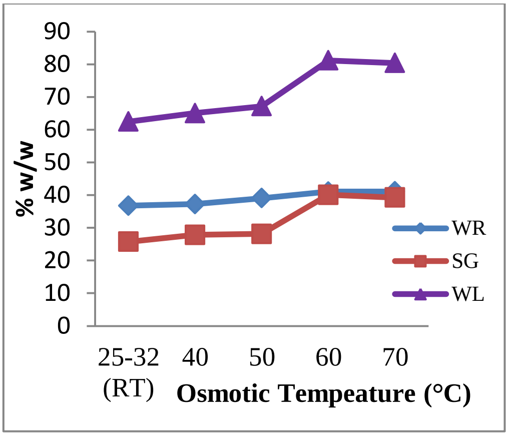


Figure 2: Effect of Osmotic Temperature on Weight Reduction, Solute Gain, and Water Loss for Osmotic Dehydration of Nga-yant

According to the Figure (4), it was found that the falling rate was occurred at the drying temperature of 80°C. So that, the drying rate is governed due to the intense internal water and vapour flow. The results of drying rate constant (k) of fishes are shown in Figure (5) and (6), by using first order drying kinetic equation (Lewis equation). From the results, values of R^2 were 0.943 at the drying temperature of 80°C. It can be confirmed that drying temperature was increased with the total drying time was decreased since heat transfer increased in the process. The values of rate constant (k) were nearly constant. Thus, it was considered that the kinetics of drying of fish and meat happened to be a first order equation.

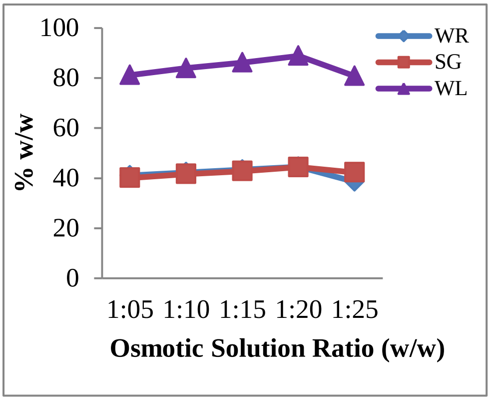


Figure 3: Effect of Sample to Osmotic Solution Ratio on Weight Reduction, Solute Gain, and Water Loss for Osmotic Dehydration of Nga-yant

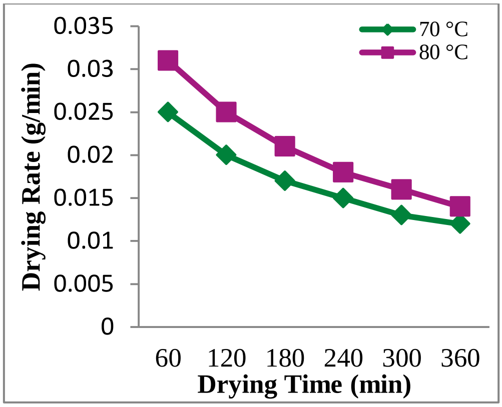


Figure 4: Drying Rate of Osmotically Pretreated Nga-yant at Different Drying Times

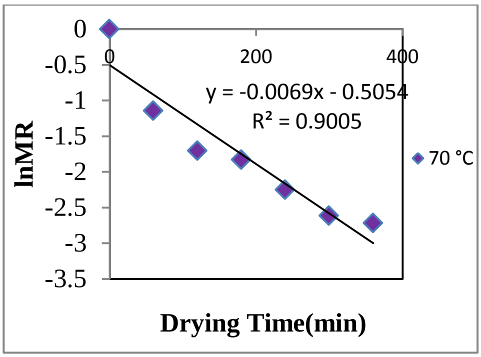


Figure 5: Drying Kinetics of Osmotically Pretreated Nga-yant at Different Drying Time at 70 °C

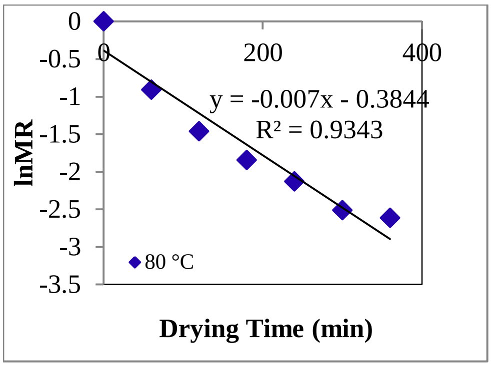


Figure 6: Drying Kinetics of Osmotically Pretreated Nga-yant at Different Drying Time at 80 °C

The physico-chemical characteristics of raw, osmo-treated dried and sun-dried fishes are shown in Table (3). It can be observed that the fish samples lose its moisture content on drying resulting in an increase in the concentration of protein and other nutrients per unit weight than in the fresh counterparts. Osmotic dehydration could improve dried food quality by stabilizing colour and allowed less colour loss of food by browning. The osmo-dried products were lighter in colour than sun-dried fishes.

Table 3: Physico-chemical Characteristics of Raw, Osmo-treated Dried, Osmo-treated Sun-dried and Sun-dried Fishes Nga-yant (Snakehead Murrel)

Sr. No.	Characteristics	Nga-yant (Snakehead Murrel)			
		Fresh	Osmo-treated Dried	Osmo-treated Sun-dried	Sun-dried
1	Moisture (% w/w)	78.39	14.6	19.67	19.62
2	Protein (%w/w)	18.74	48.46	47.42	45.23
3	Fat (%w/w)	0.17	0.74	1.02	1.69
4	Crude Fiber (%w/w)	0.00	0.14	0.00	0.13
5	Carbohydrate (%w/w)	1.70	17.76	12.78	16.93
6	Ash (%w/w)	1.00	18.3	19.11	16.4
7	Energy Value (kcal)	86	271.54	249	263.85
8	Color Density	-	0.17	0.17	0.30

Table 4: Microbial Analysis of Osmo-treated Dried, Osmo-treated Sun-dried and Sun-dried Fishes during Storage Period

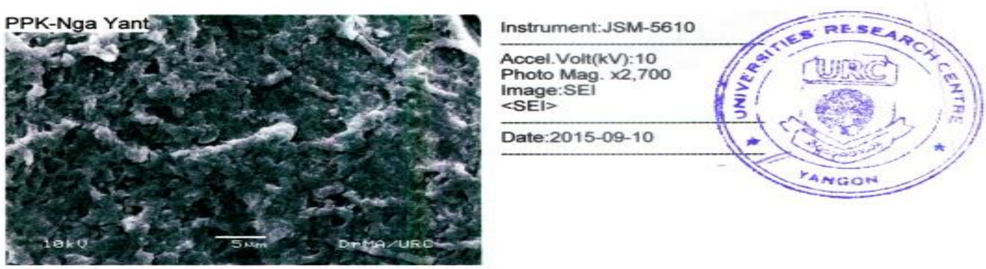
Sr. No.	Nga-yant	Total Plate Count (cfu/g) with Respect to Shelf- life	
1	Osmo-treated Dried	6 month*	2.5×10^3
2	Osmo-treated Sun-dried	6 month	3×10^3
3	Sun-dried	6 month	3×10^3

* Shelf-life of osmo-treated dried Nga-yant was 6 month period.

Table 5: Organoleptic Properties of Osmo-treated Dried, Osmo-treated Sun-dried and Sun-dried Fishes

Sr. No.	Nga-yant	Sensory Scores for Hedonic Scale Rating Test			
		Appearance	Flavour	Texture	Overall Acceptability*
1	Osmo-treated Dried	7.6	7.4	7.4	7.47
2	Osmo-treated Sun-dried	7.4	7.5	7.4	7.43
3	Sun-dried	7.1	7.5	6.8	7.13

*Score about 7 was good quality products.



(a)Sun-died

(b) Osmo-treated Dried

Figure 7: SEM Images of Dried Nga-yant (Snakehead Murrel)

(a) Fresh (b) Osmo-treated Dried (c) Osmo-treated Sun-dried (d) Sun-dried

Figure 8: Fresh and Osmo-dried Fishes (Nga-yant)

From the results of the TPC shown in the Table (4), it was observed that the plate count in osmo-treated dried products was lesser than the total plate count of the sun-dried products during storage period. The microbial profile of dehydrated fishes indicates that the osmotic dehydration is a hygienically safe process. The sensory evaluation results are shown in Table (5). Higher mean scores of colour and texture were observed in the osmo-treated dried samples compared to the sun-dried samples. Thus, the use of osmotic solution reduced brown colour and hard texture of fish products.

According to the SEM micrographs of Figure (7), the effect of concentration of sucrose solution on the microstructure of food during osmotic dehydration treatment can be observed. According to the Figures (7 a) and (7 b), the surface of sun-dried samples were harder than osmo-treated dried samples. The osmotic pretreatment maintain the structure of samples from undesirable structural changes.

Conclusion

Osmotic dehydration has a tremendous market potential for producing high quality food with different varieties. The effect of sucrose concentration during the process was observed to be dependent on time to improve the degree of water loss. Therefore, best processing temperature should be decided on the basis of food tissue structure. It can be concluded that osmotic dehydration is a hygienically safe process and the process could improve the sensory quality of dried fishes. The sensory scores of osmo-treated dried fishes were greater than 7, thus the products were good quality products.

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